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IMPACT OF SUPPLY CHAIN STRATEGIES ON THE LOGISTICS PERFORMANCE

Y. Ilker Topcu, Sule Onsel Sahin, Fusun Ulengin
Istanbul Technical University, Management Faculty, Industrial Engineering Department
Macka, 34722, Istanbul TURKEY,
Tel: +90 212 293 13 00, Fax: +90 212 240 72 60
e-mail: topcuil@itu.edu.tr, sahinsul@itu.edu.tr, ulengin@itu.edu.tr

Abstract

Supply chain can be defined as the chain, linking each element of the manufacturing and supply process from raw materials through to the end user, encompassing several organizational boundaries. Although supply chain management has an important effect on the firms' overall performance; there is no complete consensus about the supply chain management strategies that will be most appropriate in improving the performance of the company.

This study aims to identify the best supply chain management strategy that affects the logistics performance of the firms. For this purpose six strategies are determined: (1) managing trade-offs along the complete supply chain, (2) calculating optimal solutions, determining network configuration and flow, (3) integrating generic processes sequentially, vertically, and horizontally, (4) segmenting customers and connecting them with the right channel, (5) determining and mastering the need to coordinate and manage relationships, and (6) merging competencies and re-locating into the deepest segments of the profit tool.

In order to test the effect of strategies, a multi-methodology is proposed. Initially, a survey is conducted in order to assess the logistics experts' pairwise comparison for logistics performance metrics. An importance order of performance metrics is determined using eigenvector approach based on Analytic Hierarchy Process method. Then as a second step, to determine the best and most effective supply chain management strategy that dominates in business practice, an artificial neural network is used. The data of the neural network are based on a survey conducted with the firms of Istanbul Chamber of Commerce.

Keywords: Logistics; Supply chain; Artificial neural network; Analytic hierarchy process
Topic Area: B6 - Integrated Supply Chain Management

1. Introduction

In today's world, Supply Chain Management (SCM) is one of the basic factors for increasing the organizational effectiveness of a firm. Supply chain can be defined as the chain, linking each element of the manufacturing and supply process from raw materials through to the end user, encompassing several organizational boundaries. Many companies began to realize that it was not sufficient only on the organization itself, rather it was compulsory to include the members standing outside the organization in relationship in terms of physical and information flows. In competitive business environments, firms are striving to achieve competitive advantages to survive through an effective supply chain performance. In order to evolve a competitive supply chain, efficient SCM strategies should be used to improve the performance of the chain. However, there is no consensus about the SCM strategies that will be most appropriate in improving the performance of the company.

Otto and Kotzab (2003) defined six possibilities to look at SCM:

1. System dynamics perspective,
2. Operations research perspective,
3. Logistics perspective,
4. Marketing perspective,
5. Organization perspective, and
6. Strategy perspective.

In system dynamics perspective, the purpose of SCM is managing trade-offs along the complete supply chain and the local area of improvement is order management. In Operations Research (OR) perspective, the purpose is to calculate optimal solutions within a given set of degrees of freedom and the focal area of improvement is the network configuration and flow. In logistics perspective, the purpose is to integrate generic processes sequentially, vertically and horizontally and the integration of processes is the focal area of improvement. In marketing perspective, the aim is to segment products and markets and combine both using the right distribution channel. In other words, the focus is on get the best fit between product, channel and customer. In organization perspective, the purpose is to determine and master the need to coordinate and manage relationships through an intra-enterprise segmentation. Finally; the strategy perspective aims to merge competencies and relocate into the deepest segments of the profit tool through the analysis of the ability to partner and positioning in the chain

The basic aim of this research is to specify which of these six perspectives dominate in Turkish business practice. For this purpose, a survey is conducted with the managers responsible of the logistics activities of the top 500 firms of Istanbul Chamber of Commerce. In the survey, the logistics experts' judgments are assessed by requesting them to make pairwise comparisons for logistics performance metrics. In the second stage, according to the responses of the initial survey, pairwise comparisons of the respondents are aggregated by using the Team Expert Choice Software (www.expertchoice.com) utilizing a group decision making method based on Analytical Hierarchy Process (AHP) (Saaty, 1990) in order to get the relative importance of the performance metrics in the surveyed firms. In the third stage, a second survey is conducted to the same firms in order to reveal their current situation according to the logistics performance metrics included in the study. They are also asked to identify the strategy they are implementing. Finally, the logistics perspectives dominating in the surveyed firms are revealed through Artificial Neural Network (ANN). For this purpose, the performance metrics are aggregated as a single overall performance metric according to their relative importance revealed in the previous step. This single performance metric is then used as an output of the ANN whereas the six perspectives are used as the input of the network.

The second section of the paper analyses the current state of the art in terms of the logistics performance measurement metrics as well as the six perspectives used to measure the performance of managing the supply chain. The third section gives the framework of the methodology proposed in the paper in order to reveal the relative importance of these six perspectives. The fourth section gives the details of the case study conducted in Turkish firms according to the proposed methodology. Finally, conclusion and suggestions are given.

2. Logistics performance measurements and the six perspectives to measure the performance of managing the supply chain

In the literature on SCM, there is a wide diversity of interpretation and understanding of SCM. Each of these, in turn, leads to a different type of performance metrics to measure the performance of SCM.

In systems dynamics perspective, each local system represents an optimization echelon which converts customer orders into material requirements and finished products. All these systems are connected through the exchange of orders and they manage trade-offs. Following this perspective, an ideal supply chain would be one that produces chain-wide optimized lot sizes and adapting fast to volume changes in demand The basic drawbacks of this perspective is the uncoordinated ordering behavior, distortion of demand pattern, uncoordinated demand planning and demand forecasting, poor inventor visibility and uncoordinated manufacturing control. The basic performance metrics used in this perspective are capacity utilization, cumulative inventory level, stock-outs, time lags in the forwarding of demand information, time to adapt to changes in demand,

The OR perspective, on the other hand, sees SCM as a network which flows from the sources of production to end customers. The basic aim is to obtain a cost- minimized flow of goods trying to achieve a set of customer goals. Logistics costs per unit, service level and time to deliver are the basic performance metrics used for this perspective.

In logistics perspective, the supply chain is seen as a set of business processes. It mainly draws attention to integration problems. The ideal supply chain is accepted to be an integrated and interface-optimized process model and the performance metrics measures are basically focused on lead time, order cycle time and inventory level flexibility

In marketing perspective, the primary outputs are costs and customer service. Customer satisfaction, distribution costs per unit to make a finished product available for a customer and market share costs are the basic performance metrics used for this purpose.

Perceiving the supply chain as a set of inter-organizational relationship, on the other hand, aims to overcome functional barriers and to coordinate inter-organizational relationships. The configuration of this relationship has an impact in the profit level of the organization. In this perspective, the ideal supply chain supports the achievement of the organizations' goals. The ideal supply chain according to this perspective is based on the achievement of the organizations' goals by selecting and managing appropriate relationships between the organization and its environment. The performance metrics used for this purpose are generally related with the transaction costs, flexibility and density of relationships.

Last but not least, in strategic perspective, the ideal supply chain ensures that a new product reaches the market in time. Therefore, time to market and return on investment are the basic performance metrics used for this purpose (Otto and Kotzab, 2003).

3. Framework of the methodology

In this study, a methodology is proposed to determine the basic approach to SCM adopted in Turkish firms. The framework of the methodology used in this study is given in Figure 1. The methodology is initially based on a survey which reveals the relative importance of performance metrics according to the logistics managers of the surveyed firms. In order to aggregate the pairwise comparisons of the managers AHP is used. In the next step, a second survey is conducted in order to determine the different SCM strategies adopted by the surveyed firms. Finally, the relative importance of the performance metrics revealed from the AHP analyses of the first survey results are used to obtain the output of the ANN while the strategies adopted are treated as the inputs of the ANN. In fact, a similar approach was used by Montagno *et al*. (2002) to identify the organizational improvement strategies using ANN. However, Montagno *et al*., do not use the first three steps of the proposed methodology given in Figure 1. As a result of these subsequent steps, ANN finds the most important strategies that influence the performance of the surveyed firms. The following sections explain, initially, the basic characteristics of AHP and ANN used in the third and 6th step of the proposed methodology. In subsequent sections the details about each step is given through the application to Turkish firms.

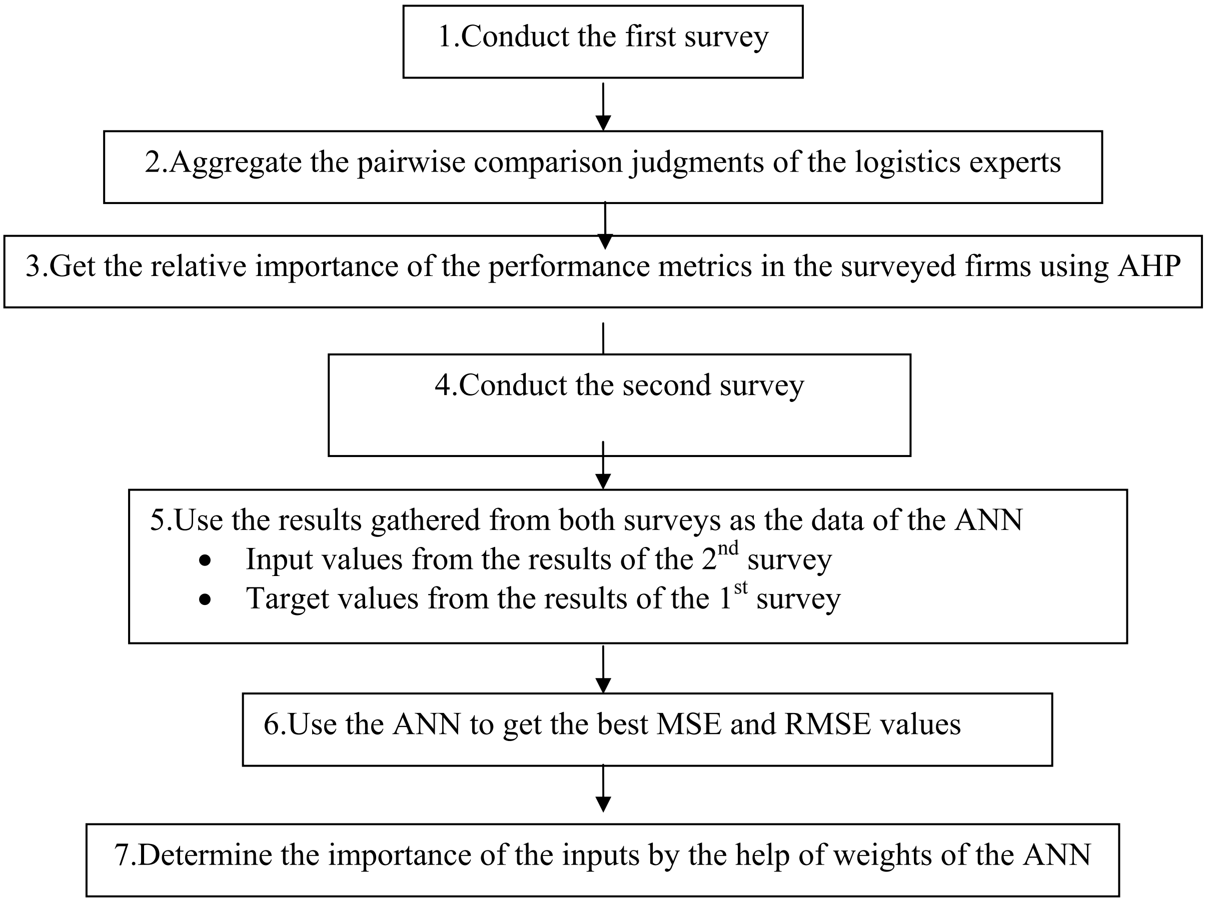

Figure 1. The flowchart of the methodology used in the study

3.1. Why to use Analytical Hierarchy Process

During decision making process, three demands are risen:

- Making decisions about a complex problem involving conflicting criteria and several alternatives is not a simple process. It necessitates a multi criteria decision making tool which can organize complexity, include subjective considerations, and synthesize information and judgments. During decision making process, the decision maker need to consider every factor related to the problem, evaluate each one, compare it to all the others, and then combine all this to reach a decision. Even though the human mind is a wonderful thing, its cognitive capacity is limited to some extent, especially in its ability to compile and analyze all the information necessary for a complex decision.
- To measure physical quantities (i.e. length, cost, weight, time), scales with units can be used. Qualitative factors (i.e. comfort, style, success) which need subjective consideration, on the other hand, can not be reasonably assessed in terns of physical measurements. Feelings and discriminations permit decision maker to develop

relationships among the factors and to determine which factors have the greatest impact. A special constructed scale should be used to assess subjective consideration.
- Furthermore, objective and subjective inputs should be merged into a single overall measure which recommends decision maker a solution to the problem. The tool should consider all of the decision maker's information and judgments simultaneously and in relation to each other to reach a decision.

AHP is a tool that can meet all these demands (www.expertchoice.com). It can organize complexity by representing the decision problem in a hierarchical form: the goal (main objective) at the top, criteria at the second level, sub and sub-sub criteria below these criteria level (if necessary), and finally alternatives at the bottom. Subjective considerations can be assessed by using a special 1-9 ratio scale proposed by Saaty. AHP captures priorities from paired comparison judgments of the elements of the decision with respect to each of their parent criteria. Paired comparison judgments can be arranged in a matrix. Priorities are derived from the matrix as its principal eigenvector. If the assesment can be made with an objective measurement, the data is normalized to get an eigenvector so that AHP can combine both qualitative and quantitative information. As a result, the relative rankings of alternatives are computed. Any choice or ranking problem can be solved by using AHP. Besides, AHP has a very user friendly and popular software, Expert Choice, which makes tha all math for the decision maker.

Most of the problems confronted at organizations are not personal decision making problems. A group of decision maker should make decisions for public and private corporate, business, administration (local, governmental…) problems. AHP can also handle such problems by utilizing Team Expert Choice software. Actually, in group decision making, AHP takes the geometric averages of judgments (paired comparisons) of different decision makers and fills a unique paired comparison judgment matrix for each parent node. Team Expert Choice can support executive decisions and establish forums for group decisions by communicating the recommended decision, justifying the rationale for that decision, and reviewing the decision answering what-if questions.

In this paper, taking into consideration the given characteristics of AHP, Team Expert Choice is utilized in order to aggregate the pairwise comparison judgments of logistics experts assessed at the initial survey and also in order to compute the relative importance of the performance metrics in the surveyed firms by using these aggregated judgments. As mentioned before, the relative importance would be used for aggregating the performance metrics as a single overall performance metric which will then be used as an output of ANN at a later step.

3.2. Why to use Artifical Neural Network

In this study, the selection of the most important SCM strategies is realized through an ANN. The basic idea behind using ANN was to specify the variables (strategies) that have the highest weights in determining the performance level of the firms. For this purpose, the SCM strategies are used as inputs and the performance as the output of an ANN model. By calculating the weights of the ANN, the SCM strategies, which have relatively high weights, are accepted to be those that have the greatest impact on the performance of the firms.

ANNs represent a collection of mathematical models that provide an alternative to conventional statistical prediction techniques. While other popular techniques, such as linear regression, identify the linear trends in data, neural networks are particularly useful in recognizing patterns in data. The literature (Swanson and White, 1997; Boznar et al., 1993; Hwarng and Ang, 2001) suggests the potential advantages of ANN over statistical methods. One such advantage is better performance of ANN when extreme values exist.

Another advantage of ANN is that the estimation of an ANN can be automated, while the regression and ARIMA models must be re-estimated periodically whenever new data arrives. Especially when it is necessary to work with nonlinear data, ANN gives better results than the traditional methods (Gately, 1996). In fact, one of the primary applications of ANN is in understanding complex nonlinear mapping (Hruschka, 1993). It has been proved that a network with only one hidden layer is enough to approximate any continuous function. Therefore, ANN might represent a viable alternative to econometric techniques. Besides, ANN performs better in terms of mean absolute error (MAE) and mean absolute percent error (MAPE) (Hwarng and Ang, 2001). Moreover, neural networks are also better in capturing turning points. This is why in this study ANN is proposed for determining the importance of the major driving forces via estimation.

The basic model of ANN techniques consists of computational units, which emulate the functions of a nucleus in a human brain. The unit receives a weighted sum of all its inputs and computes its own output value by a transformation or output function. The output value is then propagated to many other units via connections between units. In general, the output function is a linear function- a threshold function in which a unit becomes active only when its net input exceeds the threshold of the unit, or a sigmoid function, which is a non-decreasing and differentiable function of the input. Computational units in an ANN model are hierarchically structured in layers. In the ANN literature, the process of computing appropriate weights is called “learning” or “training”. The learning process of ANN can be thought of as a reward and punishment mechanism (Hruschka, 1993). When the system reacts appropriately to an input, the related weights are strengthened. As a result, it will be possible to generate outputs, which are similar to those corresponding to the previously encountered inputs. Contrarily, when undesirable outputs are produced, the related weights are reduced. Therefore, the model will learn to give a different reaction when similar inputs occur. Thus, the system is motivated toward producing desirable results while the undesirable ones are “punished”.

Currently, there are many different learning algorithms, which work with different types of output function in various network architectures (Masters, 1993). One of the most popular neural network paradigms, which are also used in this study, is the feed-forward neural network and the associated back-propagation training algorithm. The back-propagation algorithm consists of two steps: the forward pass and the reverse pass (Chiang et al., 1996; Tang and Fishwick, 1993). In the forward pass the input unit simply passes on the input vector x. The units in the hidden layer and output layer are processing units. Each processing unit has an activation function, which is commonly a sigmoid function.

$$f(x) = \frac{1}{1+e^{-x}}$$

The net input to a processing unit j is given by

$$net_j = \sum_i w_{ij} x_i + \theta_j$$

where x_i’s are the outputs from the previous layer, w_{ij} is the weight of the link connecting unit i to unit j, and θ_j the bias, which determines the location of the sigmoid function on the x-axis.

A feed forward neural net works by training the network with known examples. A random sample (x_p, y_p) is drawn from the training set $\{(x_p, y_p) \mid p=1,2,..,P\}$ and x_p is fed into the network through the input layer. The network computes an output vector o_p based on the hidden layer output. o_p is compared against the training target y_p. A performance criterion function is defined based on the difference between o_p and y_p. A commonly used criterion function is the sum of squared error function:

$$F = \sum_p F_P = \frac{1}{2}\sum_p \sum_k (y_{pk} - o_{pk})^2$$

where p is the index for the pattern (example) and k is the index for output units.

The error computed from the output layer is backpropagated through the network, and weights (w_{ij}) are modified according to their contribution to the error function.

$$\Delta w_{ij} = -\eta \frac{\partial F}{\partial w_{ij}}$$

where η is called learning rate, which determines the step size of the weight updating.These forward and reverse passes are continually executed for each learning pair of the learning set.

Since the basic backpropagation learning algorithm is too slow for many practical problems, high performance numerical optimization techniques have been applied to provide its faster convergence. One of those is the Marquardt-Levenberg modification to the backpropagation algorithm, which is described by Hagan&Menhaj (1994). While basic backpropagation is a steepest descent algorithm, this algorithm includes an approximation to the Newton's method. The update formula,

$$\underline{x}_{k+1} = \underline{x}_k - \left[J^T(\underline{x}_k)J(\underline{x}_k) + \mu I\right]^{-1} J^T(\underline{x}_k)\underline{e}(\underline{x}_k)$$

is used where $\underline{e}(\underline{x})$ is the vector of network errors and $J(\underline{x})$ is the Jacobian matrix. The Jacobian is computed by a simple modification to the standard backpropagation algorithm. When the parameter μ is large, the algorithm becomes steepest descent and for small μ values it becomes Gauss-Newton. Thus, when a step result with an increased performance function, μ is multiplied by some factor (β), while after a step reducing the performance function, μ is divided by β. It has been found that the Marquardt algorithm is quite efficient in training networks with up to a few hundred weights.

The aim of training a neural network is not only minimizing the sum of squared errors for the training data set, but also providing a good generalization ability for the network. Regularization and early stopping are two methods to overcome this generalization problem. It is shown for linear networks that under optimal parameter settings, these two methods have equivalante generalization performances (Hagiwara, 2002). However, using regularization seems to be more suitable when the size of the data set is small -as in our case-, since it does not require an additional validation data set.

Generally, the aim of the training is to minimize sum of squared errors. Regularization adds an additional term to this objective function, so it becomes $\beta E_D + \alpha E_W$, where E_D is the sum of squared errors, E_W is the sum of squared weights and β, α are the parameters. The Bayesian technique is an approach for the optimization of these objective function parameters. Foresee&Hagan (1997) propose that if the Marquardt-Levenberg algorithm is used to achieve Bayesian optimization, the additional computation for optimization of the regularization is minimal. In this paper, their approximation to the Bayesian regularization, which is in combination with the Marquardt algorithm, is used. With the use of this algorithm, whatever the number of total parameters (weights and biases) is, the effective number of parameters remain approximately the same; so does the E_D and E_W function values.

In multilayer neural networks in order to determine the characteristic of each input neuron and the strength of the connection between input X_i and output O_i, different weight

$$RS_{ji} = \frac{\sum_{k=0}^{n} (W_{ki} * U_{jk})}{\sum_{i=0}^{m} \left| \left(\sum_{k=0}^{n} (W_{ki} * U_{jk} \right) \right|}$$

measurement techniques can be used. One such a measure is proposed by Yoon et al. (1993).

In this formula, RS_{ji} is the strength of the connection between input i and output j. W_{ki} is the weight between the hidden neuron k and input neuron, while U_{jk} is the weight between output neuron j and hidden neuron k. This statistic, in fact, is the ratio of strength between input i and output j to the total strength of all input-output neurons. The absolute value in the denominator is used to eliminate the negative relations between input-output neurons.

The absolute value of the weights connecting the input neurons to the hidden neurons is another measurement that can be used. In this measurement, the inputs that are connected to hidden units with weights about zero are expected to have little impact on outputs. In some of the ANN software this measurement is used after training and the sum of weights of each input is determined in order to rank the inputs according to their strength (Gately, 1996).

The third measure is based on sensitivity analysis proposed by Masters (1993). The importance of the input can be put forward by the error ratio determined from the training data set by fixing one of the inputs and analyzing its effect on the error ratio. That is, if an important change is not determined, the related input is put backwards in the resulting importance ranking. If the analyzed input value is set to zero, its impact on the error of thetraining set can be analyzed easily.

In this study all of the three methods mentioned above are used for estimating the importance of the inputs of the ANN.

4. Case study of Turkey

4.1. The results of the surveys

This study aims to investigate the most important SCM activities that play key roles in the firms' overall SCM performance. As it is described in the above section, by examining the weights of the neural networks, one can easily determine not only the relevant SCM activities but also the order of their importance. In order to find the input data of the ANN, in the initial step, a survey is conducted with the top 250 firms, member of the Istanbul Chamber of Commerce. In this research data were collected through a structured 7-page mail survey. A pre-test was conducted with 10 firms to avoid inapplicable questions and ambiguous wording. The questionnaire are sent by mail and e-mail. The mailing was done in two stages. All non-respondents to the first stage were sent a second survey by fax and were requested to respond either by fax or by e-mail. Some of the firms were directly visited and the responses were obtained through depth-interview. As a result, a total of 55 questionnaires were obtained, representing a 22% response rate.

The questionnaire was designed to analyze the most important strategy (ies)n that should be used by an organisation in order to have a successful supply chain and it was directedto the manager of the orginisation responsible from the supply chain activities.

Three main types of variables were included to analyze the impact of supply chain strategies to the success of the organization.

a. **Profile-Based Variables**: Industry in which the firm operates, duration of operation, number of employees, existence of a foreign partnership, gross revenue, sector in which the firm operates, the basic markets that is served (foreign, national or both), the existence of a foreign partnership, the number of blue- collared and while- collared workers. Nominal and ratio scaled open-ended questions are used in order to measure majority of the profile-based variables in the questionnaire. Perceived position of supply chain activities is also measured by a multiple-choice question that investigates the relative position of supply chain activities with respect to production, marketing, purchasing, research and development, human resource management and other activities within the organization.

In this study, the majority of surveyed companies are middle or large size companies with a gross revenue greater than $50 million (53%) and with the number of employee higher than 500 (77.2%).The majority are in the food (25%) and textile sector (32%) and do business both in national and international markets(70%) (see Table 1)

Table 1. General and Organizational Characteristics of the Firms

Operating Area	**(%)**	**Number of Employees**	**(%)**
Food/Beverage	25	-500	37
Clothing /Textile.	32	501-1000	43
Durable consumer goods (automobile, white appliances)	17	1001+	34.2
		Market structure	**(%)**
Electronics/Communication	10	Priority is given to international markets	22
Basic Industry (iron/steel, paper, mine, plastics etc)	14	International and national markets equally served	35
Other	2	Priority is given to local markets	35
		Only international markets	5
		Only national markets	4
		Gross income	**(%)**
		<50	47
		50-100	29
		100+	24

The surveyed firms especially emphasizes the importance of production (91.3%) in the success of a company, followed by marketing(86%) and finance(82%). Supply chain is at the fourth level (78%) and therefore its importance is not yet clearly understood by the respondents firms. The majority believe that their most dominant supply chain strategy is to adapt the supply chain activities to the changing conditions (36%) and to integrate all the supply chain activities rather than treating them individually (25%)

b. **Variables related to Supply Chain Management Strategies**: In this second group of variables, the supply chain strategies adopted by the surveyed firm in order to improve the effectiveness of the logistics functions are analysed. The surveyed firms are offered six strategies and were asked to reveal the dominant strategy used in their firm. In a case where more than one strategy is use, the firms were asked to rank them in their order of importance. The strategies investigated in this study are namely:

- to treat all the SCM activities in an integrated manner rather than individually (System dynamics perspective),
- to use modelling techniques to optimize SCM activities (OR perspective),
- to provide vertical and horizontal integration among the SCM processes (Logistics perspective,

- to direct to the suitable distribution channel by appropriate segmentation of the product and the market (Marketing perspective),
- to minimize the organisational conflict concrning SCM activities (Organisational perspective),
- to adopt SCM activities to the changing conditions (Strategy perspective)

c. **Variables related to the Success Level of the Company Based on Performance Indicators in Different Areas:** The logistics performance metrics examined in our study is based on the SCOR metrics (www.supplychain.org) and includes five basic metrics such as "reliability", "responsiveness", "flexibility", "cost improvement", and "effective management of assets". There are also fifteen sub-metrics under these basic metrics. Table 2 shows the basic metrics as well as the sub-metrics under each basic category.

Table 2. Logistics Performance Metrics

RESPONSIVENESS
Customer satisfaction with order fulfillment lead time
COST IMPROVEMENT
Minimizing cost of goods sold
Minimizing cost of total SCM
Minimizing warranty cost or returns processing cost
RELIABILITY
Delivery performance
Damage-free delivery
Consistency of delivery time
Perfect order fulfillment
The fill rate
FLEXIBILITY
Supply chain response time
Production flexibility
EFFECTIVE MANAGEMENT OF ASSETS
Inventory days of finished goods
Cash-To-Cash Cycle Time
Efficiency of capacity utilization
Efficiency of asset turns

4.2. The relative importance of the logistics performance metrics

In he first survey, logistics experts of the surveyed firms are given pairwise comparison matrices and asked to fill them based on a 9-scale as proposed by Saaty (1990). The pairwise comparison judgments of the logistics experts in the surveyed firms were aggregated and the relative importance of the performance metrics were computed utilizing Team Expert Choice. The results are given at Table 3.

As can be seen from the table, the most important metric of the logistics managers in the surveyed firms was found to be "Delivery performance", followed by "Minimizing cost of goods sold", "Minimizing cost of total SCM", and "Damage-free delivery". As can be seen, therefore, the sub-metrics corresponding to "Reliability" and "Cost Improvement" are accepted to be more important than those of other metrics by the logistics managers of the surveyed firms.

Table 3. The relative importance of the metrics

Sub-Metric	**Basic Metric**	**Importance**
Delivery performance	Reliability	335
Minimizing cost of goods sold	Cost improvement	315
Minimizing cost of total SCM	Cost improvement	309
Damage-free delivery	Reliability	305
Consistency of delivery time	Reliability	285
Customer satisfaction with order fulfillment lead time	Responsiveness	282
Inventory days of finished goods	Eff. mng. of assests	176
Supply chain response time	Flexibility	150
Production flexibility	Flexibility	138
Cash-To-Cash Cycle Time	Eff. mng. of assests	128
Perfect order fulfillment	Reliability	125
Efficiency of capacity utilization	Eff. mng. of assests	96
Minimizing warranty cost or returns processing cost	Cost improvement	90
Efficiency of asset turns	Eff. mng. of assests	60
The fill rate	Reliability	55

4.3. The relative position of six perspectives

In order to identify the relationship between the SCM strategies adopted by the surveyed firms and their logistics performances, ANN is used. For this purpose a second survey is conducted with the logistics managers of the same surveyed firms and, they were asked to identify the strategy they are implementing. Due to the fact that the fifth strategy (namely the organizational perspective) is not selected by any of the surveyed firms, the ANN used in this study has 5 inputs instead of 6 mentioned by (Otto and Kotzab, 2003). The output representing the overall logistics performance of the firm is determined by computing the weighted average of responses related to logistics performance metrics revealed at the first survey. AHP weights of the sub-criteria assessed at the end of first step are used as weights for this computation.

As it can be seen from Figure 2, the ANN architecture used in this study has only one hidden layer. As generally prefered for feedforward networks, a sigmoid function, hyperbolic tangent, is used for the hidden layer and a linear transfer function is used for the output layer. 43 data at hand were used for training and 4 data were used for test purposes. In order to determine the appropriate number of hidden neurons, networks were tried with the number of neurons beginning from 2 to 12. Every network was trained several times starting with different initial weights to guarantee robust performance. Training is continued until convergence is achieved, that is the sum squared errors, the sum squared weights and the effective number of parameters became constant.

As expected from the special training algorithm used, the performances of the networks were close. However, the network with 2 hidden neurons gave the best acceptable performance value for both the training and the test data sets. The mean square error SSE values for train test datas are 0,00038 and 0,000046 respectively.

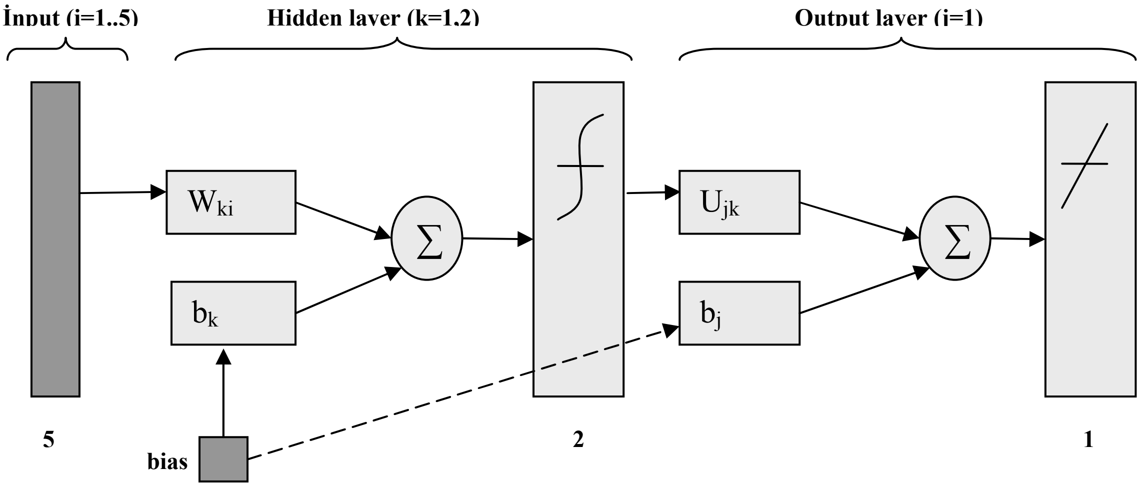

Figure 2 The ANN architecture

In order to determine the characteristic of each input neuron and the strength of the connection between input X_i and output O_i, each of the three weight measurement approaches is used and the average of all the three measures is taken. The results of the three measurement as well as the average values are given in Table 4.

Table 4. The Results of the Importance Measurements

SCM Strategy	Sensitivity Analysis	Absolute Value Measurement	Yoon's Measurement	Average Value
1	0,112742498	0,06851193	0,068513565	0,083255998
2	0,060321309	0,100701226	0,100703469	0,087242001
3	0,228023644	0,380612864	0,380606762	0,329747756
4	0,243634435	0,325363353	0,325363092	0,298120293
6	0,355278115	0,124810627	0,124813112	0,201633951

The first measurement is based on sensitivity analysis proposed by Masters (1993). The importance of the input can be put forward by the error ratio determined from the training data set by fixing one of the inputs to zero and analyzing its effect on the error ratio. From the results of the sensitivity analysis, it can be seen that the most important input, that has the greatest effect on the output is the 6th strategy (0.355). The second measurement, namely Absolute Value Measurement, is based on the absolute value of the weights connecting the input neurons to the hidden neurons proposed by Gately (1996). In this measurement, the inputs that are connected to hidden units with weights about zero are expected to have little impact on outputs.From this perspective, the most important input is the 3rd strategy (0.38). The last measurement is the one proposed by Yoon et al (1993). The formula (1) is slightly changed by taking the square of both the numerator and the denominator in order to make it more effective and thus making the sum of the weight equal to 1. The value calculated, is the ratio of strength between input i and output j to the total strength of all input-output neurons. Again, the most important input is the 3rd one according by the Yoon's measurement.

The relative importance of the 5 strategies depending on the average values are shown in Figure 3. The ANN results underline that the most important supply chain strategy influencing the logistics performance of the firms is the Logistics Perspective (No 3) integrating generic processes sequentially, vertically and horizontally. In other words, the application of the Logistics perspective is the most important strategy playing the important role in the overall performance of the logistics activities in the surveyed firms. This is followed by the Marketing Perspective (No 4) concerned with segmenting customers and connecting them with the right channel. The third most important strategy is based on the Strategy Perspective (No 6) which is concerned with the adaptation to changes in the environment such as merging competencies and re-locating into the deepest segments of the profit tool However, according to the ANN results, the surveyed firms do not believe in the importance of the OR perspective (No 2), based on calculating optimal solutions and determining network configuration and flow. Similarly the System Dynamics Perspective (No 1), which is based merging competencies and re-locating into the deepest segments of the profit tool is not of primary importance in the overall logistics performance of the surveyed firms. Besides, as was mentioned before, none of the firms use the Organizational perspective (No 5) which is based on determining and mastering the need to coordinate and manage relationships.

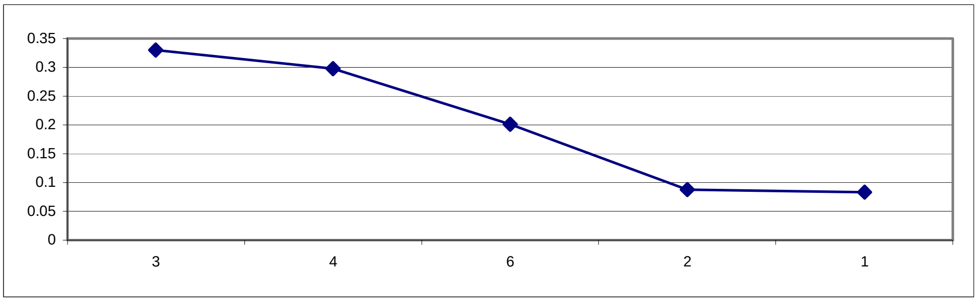

Figure 3.The relative importance of the SCM Strategies

5. Conclusions and further suggestions

This study aims to provide a tool for the selection of the best SCM strategy(ies) to improve the overall supply chain performance level of the company. ANN is used as an aid to decision making. The inputs of the ANN are taken to be five SCM perspectives revealed to be used by the surveyed firms.

Analyzing the weights of the related ANN helps us to specify the strategies that have the greatest impact on the SCM performance level. This study does not claim to prescribe one strategy over the other, it offers the current picture of the Turkish firms and help them to examine the success level of them and the basic strategies that contributed to their success. The strategies having the highest weight appear to be the approaches that have the highest impact on the overall SCM performance of the firms when used independently. In the surveyed firms the basic perspectives contributing to the overall performance of the supply chain activities are the Logistics, Marketing and Strategy Perspective. The Turkish firms do not yet get an important positive impact from the optimization models and trade-off analysis as well as from the reconciliation of the organizational conflict between different logistics units.

As can be seen from the results, different SCM perspectives lead to different performance measures. In fact, none of these approaches provide an optimum. Instead, from the holistic point of view, the different performance measurements should be combined. However, the Turkish firms especially focus on performance metrics based on "Delivery Performance", "Minimizing cost of goods sold", "Minimizing cost of total SCM", and "Damage-free delivery". As can be seen, therefore, the sub-metrics corresponding to "Reliability" and "Cost Improvement" are accepted to be more important than those of other metrics by the logistics managers of the surveyed firms. As a result, the basic perspectives are those related especially to those metrics. Therefore, the focal areas of improvement are accepted to be the integration of SCM processes, the fit between product, channel and customer position in the chain as well as the flexibility of adapting their position in the chain according to changing circumstances .

A successful supply chain requires real-time information regarding the goods' delivery status, immediate notification of delays and other delivery problems, storage, order processing and retrieval and communication among all partners in the global chain. Information Technology (IT) and OR play a dominant role in the realization of those interfaces. IT is defined here as the hardware, software, and network communication instruments. However, the participant firms do not emphasize the importance of finding the optimum SCM network configuration, the necessity of managing the trade-offs along the complete supply chain. This may be due to the fact that they still see SCM activities as cost absorbing activities rather than strategic activities that may increase their global competitiveness. These findings are also in parallel with those revealed by Uray and Ulengin (2004) which show that the IT in general and Internet in particular are widely used by Turkish firms only in their communication with both customers and suppliers. They use the Internet to communicate with both groups by sending visual and verbal product information. Firms having a website appear to have more benefited from its ability to activate communication with customers than suppliers. The use of OR-enabled IT to gain strategic advantage, for example in order processing, tracking and tracing of real-flow capabilities are necessary components for competing in today’s market. In fact, the growing gap between OR research and the average business process in the average company duggests that there is much potential for a company to gain strategic advantage by using OR-enabled IT (Sodhi, 2003). However, Turkish firms appear to underestimate the importance of such activities.

The main limitation of this research is due to the limited number of returned questionnaires. In order to increase the validity of the results, the survey size should be increased. For example, the differences in SCM perspective may be depending on their size, on the existence of a logistics department, on the sector in which the firm operates and on the perceived position of supply chain activities in the firm. However, those differences cannot be distinguished due to the limited number of the returned questionnaires. Similarly, such an increase will also permit to analyze the differences among the sectors in terms of the importance that they attach to the strategies and detailed multivariate analysis such as factor analysis and cluster analysis can also be applied.

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